OBSERVATIONS ON ANENCEPHALY.

A Thesis for the Degree of Doctor of Medicine

of the University of Edinburgh,

by

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Observations on Anencephaly.

An apology may seem necessary at the outset for choosing the subject of this thesis from the ever seductive field of the extraordinary and the anomalous, when the medical curriculum abounds in suggestions of topics which might appear to have a greater claim on the attention, if only from the standpoint of their more obvious practical utility. Interest and opportunity plead in explanation, an interest awakened by my being privileged to attend the first series of lectures delivered on Antenatal Pathology, by Dr. Ballantyne in the University of Edinburgh, and opportunity by the provision of material through the kindness of Prof. Leith and the Curators of the Pathological Museum of the University of Birmingham where my attention was invited to the Teratological collection and where some unmounted specimens of anencephaly were placed at my disposal for examination.

Before entering on a description of this material, which, with data obtained from perusal of the literature on the subject, has furnished me with the basis of my research and critical exposition, I shall allude to the classification and definition of anencephaly.

By the light of the Torch of Learning held in the hands of our modern Teratologists, the pages of this section of the Volume of Pathology are so illuminated that the subject matter is becoming more intelligible. Our attention is now directed to the

scientific reading of the etiology and morbid anatomy of the phenomena that characterise this branch of pathological morphology. The cause of the anomalous is being brought more within our ken and its remedy within the bounds of possibilty. While the Pessimist is sunk in gloomy contemplation of the vicious cycle of degenerate stock, with the inevitable perversion of the embryo resulting in anomolous forms, themselves the subjects and progenitors of deformities, and of the fatalistic doctrines of the ultimate destruction of the unfit as part of Nature's scheme, the Optimistic Philosopher and Social Reformer, who believes in the efficacy of free will, or the guidance of religious spirit or scientific instruction, has the assurance and encouragement of Dr.J.W.Ballantyne's faith in the vis medicatrix naturae, and the possibilities of the personal factor in eugenesis for the physical regeneration of the human race.

"The strong Will and the Endeavour
That forever

Wrestles with the tides of Fate".

Turning to the general aspects of the subject we find that the study of anomalies sought to be ranked as a science under the name "Teratology" given to it by Etienne Geoffroy Saint Hilaire, a term which could no longer be associated with superstitious ideation, and Förster, by giving it the title of "Pathology of the Embryo", allotted it a place in the Scientific Household. A proper conception of the true nature of the

anomalous follows upon the recognition of the way in which age incidence modifies the results of the action of morbid agencies on the organism. These morbid agencies acting during the process of its formation produce aberrations of form. This has been practically illustrated by Camille Dareste's experiments on the embryo. His morbid agents produced malformations. Malformation is therefore a term containing a definition, the definition of teratology, and the explanation of the teratological condition anencephaly.

Varieties of malformation repeat themselves in certain well defined types, which however do not readily fall into classes. The multitude of systems of classification, all more or less unsatisfactory, proves that for want of sufficient data an accurate and really scientific classification of anomalies is at present impracticable. We must rest content with a provisional one which on the grounds of general utility will aid the systematic study of the subject. Such a classification is the one adopted and modified from Taruffi by Ballantyne. Although it does not pretend to be more than a convenient method of grouping together teratological formations yet it gives a collective view of the subject, and for that reason I quote it here, elaborated from the text, in its relation to the condition under consideration.

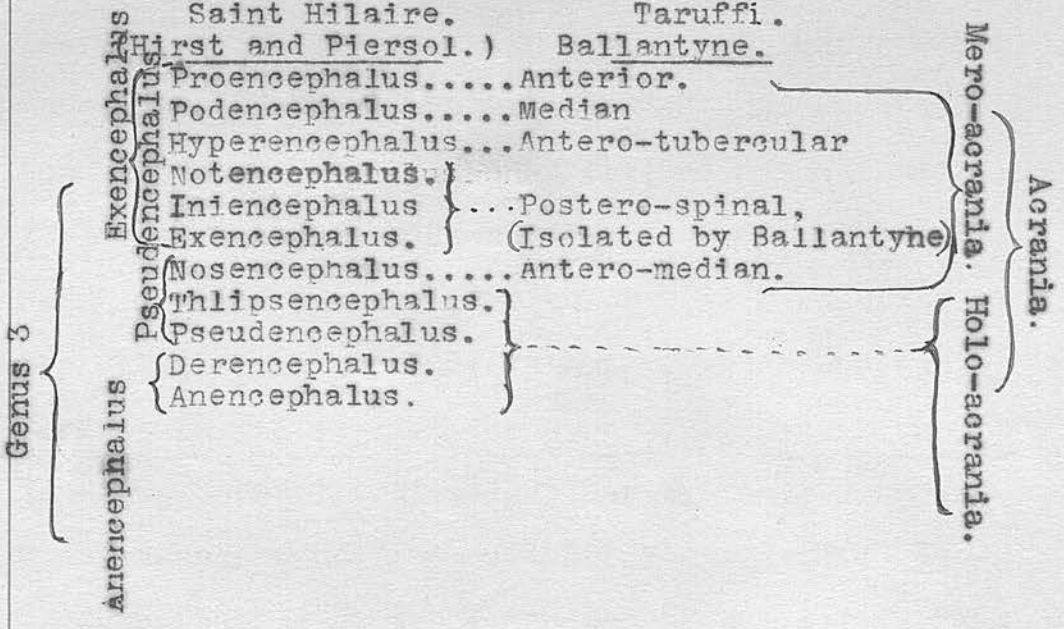
Terata.

A. Monosomatous.
   1. Pantosomatous.
   2. Merosomatous.(a regional classification of types adopted).
      .Anomalies of the cranium and its contents.
      Type,Anencephaly (acrania).
      (a).Mero-acrania.(partial acrania).
      Anterior;
      Median.
      Antero-median
      Antero-tubercular.
      (b) Holo-acrania.(complete acrania).
   3. Heterotaxic.
B. Polysomatous.

The use in the text of the term pseudencephaly, by Ballantyne[1], exposes the inadequacy of a purely acranial nomenclature for comprehensive descriptiveness but we must not be too critical in this matter. At present it is as difficult to name as to classify the anomalous and Ballantyne's reiterated hint at the ultimate solution of the latter difficulty in the grouping of anomalies according to the period of antenatal life in which they originate, forms one of his many interesting speculations.

Successive systems of classifcation have slightly modified the conception of the condition anencephaly. The term was restricted by Saint Hilaire to monsters without any trace of brain or cord, whose cranial vault was absent and the spinal canal open. The limitaions of this variety of malformation were slightly altered in Taruffi's definition. He used the term acrania, thus accentuating the idea of the

osseous defect and limiting it to the region of the head, leaving the spinal condition as an associated malformation. In addition, he included Saint Hilaire's whole genus 3. of the first Order of single monsters. Ballantyne modifies the conception of the condition still further by isolating Taruffi's 5th group as a separate teratological state in which the nape of the neck is the region affected. This leaves us with his definition of anencephaly as "a teratological state of the head in which the osseous vault of the cranium is more or less defective, in which the scalp is absent in whole or in part, and in which the brain in more or less gravely altered and may even be entirely wanting." I subjoin the following tabulated scheme extracted from Hirst and Piersol, and from Ballantyne, arranged to facilitate a relative comparison of these systems of classification.



Here we have the type anencephaly isolated from the other members of the cephalo-terata of which cephalocele is an example (distinguished principally by the presence of the scalp), and shaking off it's connection with iniencephaly as a type and the members of the rachi-terata, extremes blending in those conditions where the cerebro-spiani canal is open from end to end. In it's complete form (holo-acrania) the condition is limited to the offspring of the human race, of which it is the commonest monstrosity. A complicated, premature labour, resulting in the birth of a stillborn female foetus whose exaggerated deviation from normal development, the product of early intraterine pathology, gives it that strange and even inhuman appearance which entitles it to the name of monster. The trunk is plump and well developed, contrasting with the small deformed crownless head, chiefly made up of face, set in an attitude of extension without the intervention of a neck, so that the misshapen ears rest on the relatively broad shoulders. The hideous, chubby, rounded face with its broad flattened nose, prominent lower jaw and partly open mouth showing the protuded tongue, is surmounted by the voluminous eyes bulging out of their shallow sockets on the edge of the open skull, where the membrane covered projections, on the narrow convex cranial base uncovered by bone, lie encircled in tonsure fashion by the deficient hairy scalp. This picture would be at fault if it concentrates the

attention too much on the condition anencephaly, as a monster per se apart from the idea of it as a malformation associated with other malformations. It is interesting in this connection to find anencephaly along with other malformations where a single individual is involved, and also to find it as a complication of an anomaly where two or more individuals are involved.

I shall now describe and comment on the twenty-four cases that I have classified and examined for the purposes of this Thesis. I studied the osseous system in four by the aid of skiagrams and dissection, prepared the skull in one case and had photographs taken of it and also of a normal foetal skull for comparison. I examined the suprarenals in three cases, had photographs taken of them and prepared microscopic sections of them, and of the pituitary bodies and eyes. The pectoral region was examined in two cases for the musculus sternalis. I determined the sex in eighteen cases, and took shoulder measurements in ten and also in the same number of normal foetuses for comparison. One of the cases recorded occurred in my own practice. There is also a short report on the specimens of Anencephalus in the Teratological collection of the Royal College of Surgeons of England, and observation on the size of the shoulders and on the sex in anencephaly.

Foetus No.1.Type, anencephaly, Subtype, holo-acrania.
Unmounted musem specimen, no clinical history.
Male. Length, 37. 5.cms. Weight, 1580 grms.
The foetus appears well nourished. There is a broad discoloured area across the abdomen (post-mortem change). Vernix caseosa is quite apparent on the body which is covered by delicate lanugo, except on the palmer and plantar surfaces of the extremities. The nails are horizontal, but do not reach to the tips of the fingers. The umbilicus is still rather low in position. The funic twist is from right to left. There is an inverted condition of both feet rather suggestive of talipes varus, but possibly due to the preservative solution in which the specimen has been kept. Both testicles are just inside the scrotum, the right at a lower level than the left.
Measurements.- The total length 37.5.cms, was made up of the sum of the measurements taken between the vertex and the acromion 5.1 cms, the acromion to the anterior superior spine of the ilium 13.3.cms, from the latter point to the internal malleolus 14 cms, and from there to the end of the hallux 5.1 cms. The foetus measured from tip to tip of the middle fingers a total breadth of 41.9 cms.
Transverse malar diameter of the face 6.3 cms, of the head just behind the ears 5.6 cms, of the shoulders 11.4 cms, and of the hips 8.6 cms. The circumference of the shoulders was 31.1 cms, of the chest 28.6 cms,

of the abdomen 25.4 cms, and of the hips 22.9 cms. Attitude and outline of the deformity as seen in the accompanying photographs. In the front view the head appears set between the shoulder, with the face looking straight forwards. There is a slight neck groove so that a piece of string passed under the double chin and between the ears and the shoulder disappears out of sight. The vertical diameter of the face from the chin to the scalp deficiency is 5.5 cms, while the transverse at the level of the malars is 6.3 cms. The eyes are prominent. The eyelids which are quite separate are fringed with eye lashes. The nose is broad and flattened, the tip being on a level with the shoulders. The tongue protudes at the open mouth. The thick folded ears stand out at the side of the head and almost touch the shoulders.

The mark across the chest is a smooth and discoloured area denuded of epithelium. The umbilicus and cord, the penis and the inverted feet, are also visible.

The lateral view, shows the face in profile, the thick folded ear, the general curve of the back and the rounded shoulders. The vertebral curvature is well seen in the accompanying skiagram. The vaultless state of the head is apparent above. It will be seen that the hairy scalp terminates a short distance above the level of the eyes, ears and upper limit of the back.

The back view shown in the next photograph shows that there is no deficiency of the skin of the back, it

ends above the shoulders in a concave hair fringed edge. The finger nails are well seen and below the incurving of the feet.

Dissection.- The defective area of the scalp measured 5.3 cms at the level of the ears, and 5.5 cms in an antero-posterior direction. The basis cranii thus exposed was covered by membrane, apparently continous with the skin margin. Posteriorly on either side the base ended in two tubercles 3.5 cms apart, the expanded extremities of the exoccipitals. A membranous pit below and between the latter and the concave scalp margin contained the circular truncated termination of the cord. Anteriorly, close to the frontal margin of the scalp in the middle line a small globular solid body about the size of a lentil projected through a circular deficiency in the membranes. This was found on subsequent dissection to be a projection on the concave posterior of a shrunken and flattened solid mass which expanded laterally into two small lobes, and covered the middle cranial fossa. Several layers of membrane and some felted dark coloured tissue adhered to the base, and brown strands entered the foramina. In the front of the dorsum sellae, which appeared as an elevated cartilaginous tubercule, there was a comparatively large body covered by membrane on the basisphenoid. When incised it was found to be soft and friable and evidently represented the pituitary body. The structures in the orbits appeared well developed, the

eyeballs were large and the sheaths of the optic nerves passed to the back of the orbit. Two small dark coloured strands, probably blood vessels entered the optic foramina one on each side from the cranial aspect. Posteriorly, the skin sent a process of fascia downwards to a strong fibrous band which bounded the open cervical canal passing up on either side along the defective processes of the upper cervical vertebrae. The dorsal muscles were inserted into this band. I then macerated the skull and, owing to the specimens having been preserved for a long period, had some difficulty in freeing the bones from the tissues adherent to them.

Description of the skull.- The vault is represented by a thin orbital rim of bone that along with a narrow horizontal plate roofs in the orbit and tails off laterally into a process which joins the everted separated supraoccipitals. These articulate with the exoccipitals and petrous temporals by cartilage. The lower part of the squamous temporal is present with its zygomatic process which articulates with the malar. The tympanic rings could be seen on the under aspect of the base on either side of the deep pharyngeal fossa separates by an interval of 8 cms. They lie inverted so that imaginary lines in the axes of the two tympanic membranes of produced would meet at a point 2cms from their under surfaces. Their position and inclination is therefore quite abnormal. The upper surface of the base which, directed upwards,

is completely exposed by the absence of the vault, except in the ethmoidal region where there is a funnel shaped cavity roofed in by that portion of the frontals lying between the orbits united by the fibrous tissue and articulating below with the two nasal bones. The narrow orbital plates end posteriorly in free borders overlapping in their outer half the great wings of the sphenoid which project externally into the orbital cavity. The orbito-sphenoids do not expand into wings laterally to articulate with the orbital plates of the frontal, but form a small horseshoe the limbs of which pass backwards, arching over the optic foramina and bounding a small triangular area of bone behind which the cartilage covered surface of the basisphenoid rises to the dorsum sellae, the highest point on the base. This separates the basisphenoid from the downward sloping surface of the basioccput. The petrous temporals and everted exoccipitals articulate through cartilage with the sphenoid and basi-occiput internally, and externally with the separated portions of the supraoccipitals hanging down on either side of the base.

The lower jaw is thick and massive and projects downwards and forwards. The rami which run parallel to each other are united by fibrous tissue at the symphysis. Each ramus measures 3.8 cms in length from the condyle to the symphysis. The outside transverse measurements at the condyles is 3.3 cms, at the angles 2.5 cms and anteriorly where the rami curve

round to the symphysis their outside measurement is 2.4 cms. The foramen magnum is incomplete posteriorly, the exoccipitals and lower portion of the squamo-occipitals are widely separated and depressed externally. The upper four cervical vertebral arches are open. The arch of the atlas ends in tubercles covered by cartilage, 2.3 cms apart. The axis has small everted incomplete processes, the odontoid process is partly ossified. The third vertebral arch ends posteriorly in tubercles that are thick and strong and are separated by an interval of 1.2 cms while the fourth arch is almost closed and cartilage unites those below. The skull is asymmetrical, the basal axis presenting a lateral curvature with its concavity to the right, making the dorsum sellae lie to the left of the middle line. The left orbit lies slightly posterior to the right one, and the left everted supra-occipital is more depressed than the corresponding one on the right side. It is interesting to note the basal scoliosis in conjunction with the same condition in the dorso-cervical region, where the concavity is in the opposite direction. For the sake of comparison I have placed alongside the anencephalic skull one of a normal foetus contrasted with which it shows some remarkable differences. As will be seen in the photographs, the anencephalic skull is flattened in appearance owing to the absence of the vault. The face is comparatively large and the receding supraorbital margins make the orbits appear shallow. The lower jaw projects beyond

the upper (hyperprognathus.) The marked arching of the base so characteristic a feature of the anencephalic skull is well shown in the photograph taken to show the open conditions of the upper cervical laminae and the absence of the foramem magnum. On side view the prominence of the dorsum sellae with the sloping basi-sphenoid and basi-occipit, producing a kyphosis of the basal axis, can be seen. The convexity of the base in anence=phaly is considered as an argument against the theory of the production of this condition by internal pressure (hydrocephalus). A contrast between the under surfaces of the normal and anencephalic skulls shows how the narrow inverted base of the latter alters the relation of its parts. Thus there is an approximation and inversion of the tympanic rings as is seen in the photograph. Alterations of the lower jaw in the approximation of its condyles and the resulting parallelism of its rami give rise to the appearance of a Norman arch while in the normal shape tends more to the Gothic. It is perhaps noteworthy as of possible atavistic interest that there is a resemblance in the shape of the mandibles in anencephaly and in the lower primates.

With the exception of the orbital plates of the frontals and the lower half of the squamo-temporals the membranous cranium is entirely absent, the lower part of the squamo-occiput which ossifies in cartilage is present as well as the other cartilage bones of the base. Ossification of other bones of the skeleton:-.

Both clavicles are well ossified. There is a single centre of ossification in the presternum, and a large centre in the os calcis, a smaller one for the astragalus. The mesosternum is not ossified. The adjacent extremities of the femur and tibia contain no centres. The head of the humerus and of the femur are alike unossified, as is also the cuboid.

A dissection was undertaken to ascertain the condition of the suprarenals. A vertical mesial incision was made through the skin from chin to pubis. The umbilical cord on transverse section showed the presence of two arteries and a vein embedded in Wharton's jelly. Both testicles had just entered the scrotum, the right being in advance of the left. The subcutaneous tissue of the body contained much fat. In the pectoral region the muscles appeared quite normal. The thoracic and abdominal cavities were opened. There was some evidence of

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of superficial postmortem change in the discolouration of the abdominal wall, and a thick jelly-like substance in the plural and peritoneal cavities. The viscera were removed en masse. Further dissection showed the presence of both suprarenals and defined their relations to the surrounding structures. A photograph was now obtained showing them in situ. They were both small, and appeared to be about the same size, although in the photograph the left looks larger owing to its lower position and better exposure. They both present their normal pyramidal appearance and to some extent preserve their usual relations to the crura of the diaphragmn, spleen and liver, but they do not more than just approximate to the upper end of the kidneys, passing for a short distance in front of them. Both Kidneys show marked lobulation especially in the left. The various viscera were separated and weighed in a delicate balance.

Total body weight		1580	grms
Thymus		5.6	..
Heart (with blood clot)		13.4	..
Lungs	right	9.3.	..
	left	6.7	..
Liver		63.5	..
Spleen		3.8	..
Kidneys	right	4.2	..
	left	2.7	..
(Suprarenals	right	.20	..
	left	.17	..

Case 2. Type, anencephaly. Subtype, holo-acrania Unmounted museum specimen. No clinical history. Sex, female. Length, 35 cms. Weight 1020 grms. The foetus is in fairly good preservation, although slight signs of post-mortem change are noticeable on the skin in front of the chest. This was more apparent on dissection when the pleural and peritoneal cavities were to contain a brownish jelly-like substance. The body is well nourished, and the abdomen appears rather prominent owing to the forward projection of the liver. The hands and feet are well formed. A fine lanugo covers the body, including the extremities, but is absent from the palms and soles. The nails are well formed, horizontal, and reach nearly to the tips of the fingers. The umbilicus is low. The cord is twisted from right to left. Vernix caseosa is present on the body. An extensively open condition of the spinal canal is present, as an associated deformity.

Measurements:- Vertex to acromion 3. 8 cms, from acromion to the anterior superior spine of the ilium 10.2 cms. From the later point to the internal malleclus 15.9 cms, and from the internal malleclus to the hallux 5.1 cms. giving a total length of 35 cms. From tip to tip of middle fingers gave a total breadth of 35.6 cms. Transverse of face (outside malar) 5.6 cms. Transverse of head, just behind the ears 6.1 cms. Transverse of shoulders 9.9 cms. Transverse of hips 7.6 cms. Circumference of

shoulders 25.7 cms. of chest 23.5 cms. of abdomen 28.5 cms, and of hips 22.5 cms.

As seen in profile the head is extended so that the face rests on the shoulders with the eyes directed upwards (uranoscopic). The nose is flattened and the mouth wide open with the tongue protruded. There is a well marked double chin over which the skin passes directly from the face on to the chest. The large expanded ears lie horizontally with their posterior borders on a level with the shoul-ders and are in the same vertical plane as the eye and scapula. The cranial vault is absent, and a membranous sac projects from the base (pseudencephally) The accompanying spina bifida can be seen extending down the back. The whole defect looks entirely backwards, and is well shown in the photograph of the back of this foetus. It measures 10 cms in length . The hairy scalp surrounds the upper part of the cranial portion of the defect in horseshoe fashion measuring 5.2. cms across at the level of the ears, while down the back the integumental margin is separated for a distance of 5.4 cms. terminating below at a distance of 6.2 cms from the anus. The lower part where the skin becomes thin, loses its lanugo and films over the deficiency, resembles somewhat in appearance the margin of a healing ulcer. The whitish area seen in the photograph a short distance above the anus (1.6 cms). is a depression that I found on dissection attached to a fibrous

band which could be traced upwards through the adipose subcutaneous tissue to the lower part of the sacrum . In the middle line of the open spinal canal the flattened rudiment of the spinal cord can be seen as a double band passing upwards between two rows of ossified projections 2.6 cms apart, to the end above at the basi-occiput. It rested on a membrane under which there was a row of ganglia on either side. The base looking directly backwards is uncovered by bone, and there is no foramen magnum A small cystic membranous sac lying on the base is adherent to the thin frontal rim. It contained some yellowish material, and from its under surface fibrous processes passed to the foramina, and in the middle line to an oval body covered by fascia on the dorsum sellae. This body was exised and placed in 10% formalin. It measured 7 by 8 mms. The eyeballs and optic nerve sheaths were intact within the orbit. These were also preserved for microscopic examination. A sagittal section through the head and neck showed a well marked cervical lordosis. This specimen was photographed. Examination of the exposed section of the base shows that the presphenoid is ossified with the basisphenoid, which is separated by a cartilaginous interval from the basiocciput. These bones rest on a fibrous basis. There was a localised thickening on two of the ribs on the right side, suggesting united fractures. There was some fusion of the vertebral bodies at the junction of the cervical and dorsal

regions. The sphenoidal angle in present to a slight degree. Ossification centres were present in the os calcis and astragalus and in the lower extremities of the femurs. The sternum was ossified in its upper segments. The cuboid was not ossified. There were no centres of ossification in the head of either humerus. I examined the muscles covering the anterior aspect of the thorax The platysma was well developed and passed downwards on to the chest embedded in adipose tissue. The right pectoralis major appeared to arise from the sternum in the usual way, but on the left side the muscle was deficient near the sternum, where a thin vertical strand of muscular tissue took its place. This was evidently the musculus sternalis, the frequent occurrence of which in anencephaly suggested to Cunningham[2] the probability of its being a reversion. Turner and Ballet held that this muscle was the rudiment of the panniculus carnosus (platysmal), but Shepherd[3] cities an instance where the platysma lay superficial to the sternalis as in this specimen, and he thinks that it belongs to the pectoral group and was inclined to consider it as a constant association of anencephaly. Windle[4] finds it present in 50% of anencephalic foetuses examined for this purpose. He points out that there are a greater number of unusual forms of this muscle met with in anencephaly than in other subjects. He found in

52 cases that it was absent in 28, present on both sides in 12, on the left side in eight and on the right in 4.

A Complete evisceration was performed in order to examine the suprarenals. Both were present but appeared abnormally small. A photograph was taken of them in situ. The left which is thicker and more pyramidal than the right just appeared above the corresponding kidney. The right suprarenal, oval and flattened, was completely hidden by the right kidney which had to be displaced in order to expose it. Both kidneys show well morked lobulation. Each of the viscera was then separately weighed. Total

Total body weight		1020	grms.
Thymus.		3.5	..
Heart(with blood clot)		12.9	..
Lungs	right	5.5	..
	left	4.8	..
Liver		63.4	..
Spleen		2.0	..
Kidneys	right	5.3	..
	left	4.8	..
Suprarenals	right	15	..
	left	17	..

The right suprarenal was preserved for microscopic examination. I now prepared the eye, the right suprarenal and the pituitary body for microscopic examination by passing them through spirit, absolute alcohol and chloroform, embedding in paraffin and

finally cut and stained sections by Van Gieson's method. An examination of an antero-posterior section of the eyeball under a low power shows the following. Microscopic sections accompany thesis.

The sclerotic and fibrous cornea the latter covered an on its outer aspect by stratified epithelium, are well seen. The choroid and iris are present. The uvea is present. The lens has a capsule, but there is no sign of the membrana pupillaris, or indeed of any portion of the vascular tunic of the lens. The vitreous humour has shrunk away slightly from the retina in which the pigment nuclear and granular layers are quite evident. The granular layer shows the usual large, small and intermediate cells, and beyond the inner molecular layer there is a narrow condensation of tissue containing nuclei, some of which belong to the ganglion cells. The retinal vessels appear on the periphery of this layer. The nerve fibre layer is not present. The layer of rods and cones is represented by a reticulate interval between the pigment cell and nuclear layers, but the structures themselves cannot be demonstrated probably owing to their having perished before the preparation of the specimen. Structures from all three formative layers, the neuroblast, mesoblast and epiblast are represented in the section. The neuroblastic structures are interesting here. In the development of the retina the outer layer of the optic cup forms the pigmentary

layer which is well shown in the specimen. Opinions appear to differ as to the part taken by the inner invaginated layer of the optic cup in the development of the retina. Gaskell[5.] maintains that only the supporting structures or fibres of Müller are formed from this layer, and that the rods, cones, and ganglionic cells are epiblastic and not neuroblastic, thus bringing the development origin of the sensory retina into line with the similar structure in the internal ear. Keith[6.] states that the ganglionic cells are more probably derived from the neuroblasts of the optic vesicle, and that these give off the optic fibres as processes. Mayou on the other hand from a study of the retina in anencephaly, considers that these processes are dependant for their development on the integrity of the nervous system. In his case the ganglionic cells were present, but the nerve fibre layer was absent as in my specimen. The conclusion which may be drawn from an examination of my specimen is that there is a structure present, the pigment layer of the retina, that is developed from an outgrowth of the alar lamina of the telencephalon, and that this part of the brain must have been present so as to form this structure, undisturbed up to the 4th week when the eye becomes independent of the brain.

The microscopical section of the suprarenal shows the presence of both cortical and medullary cells. The medulla is extremely vascular, so that the blood vessels crowd out and dislocate the relations

of the cellular elements. The cortex is also vascular but not to so great an extent. Microscopic Section ~~Slide~~ with Thesis.

With regard to the pituitary body, Ballantyne says that it is rarely seen in anencephaly There were traces of this structure in F.G. Gades' case but I have not seen its presence recorded anywhere else in the literature I have reviewed. I have looked for the pituitary body in five of my specimens and it was represented in all of them by an oval body encapsuled on the surface of the basisphenoid. The microscopic section of the one found in Case 2 shows an organised lobulated structure, the lobules demarcated by very vascular peripheries with less vascular centres in which masses of clear nucleated cells are contained within a vascular connective tissue reticulum. The whole section shows the same uniformity of structure and is evidently that portion of the pituitary body which is developed from the stomodaeum. Microscopic Sections accompany Thesis.

Description of the pituitary body from Case 8.(q.v.) Microscopically it shows a vascular reticulum containing cells, some small with clear protoplasm, others large and eosinophilous(Mann's stain). There is some shrunken neuroglial tissue,the nuclei of which are stained, but [illegible] in which there are no nerve cells.(Heidenhain's method). This neuroglial tissue lies above and in contact with the other portion which presents a uniform appearance.

Microscopic sections with Thesis.

Case 3. Holo-acrania A small female foetus with extensive spina bifida. A sagittal section shows the presence of cervical lordosis.

Case 4. Holo-acrania with extensive spina bifida male weight 567 grms. length 28.0 cms. breadth 34.9 cms. Transverse of shoulders 8.6 cms. of head 5.5 cms. of face 5.1 cms. of hips 6.3 cms. Pituitary body present.

Case 5. Holo-acrania, upper cervical spina bifida female weight 793 cms length 31.5 cms. breadth 36.9 cms. Transverse of shoulders 9.5cms. of head 5.0 cms., of face 4.3 cms of hips 6.7 cms. Photograph accompanies this record. Slight neck anteriorly.

Case 6. Holo-acrania. Extensive spina bififa, double talipes varus. female. weight 1534 grms.

Case 7. Holo-acrania, upper cervical spina bifida. Female. Weight 1227 grms. Length 36.9 cms. Breadth 37.5 cms. Transverse of shoulders 10.3 cms. of head 5.0 cms. of face 4.8 cms of hips 7.5 cms. The pituitary body present. In the photograph of this case the apparently large shoulders result from the tilting of the specimen to show the vault.

Case 8. Holo-acrania. male. upper cervical spina bifida. The pituitary body present.

Case 9. Antero-tubercular mero-acrania. male, no spina bifida.

Case 10. Holo-acrania, extensive spina bifida. female.

Case 11. Antero-tubercular mero-acrania, distant neck no spina bifida, female.

Case 12. Holo-acrania. Upper cervical spina bifida Female.

Case 13. Holo-acrania. Uoper cervical bifida. Female. Slight Neck. Transverse of shoulder 13.3 cms. of hips 9.1 cms.

Case 14. Holo-acrania with extensive spina bifida. Female. Transverse of shoulder 10.9 cms. of hips 8.3cms.

Case 15. Holo-acrania with extensive spina bifida and double club foot, talipes varus of left and valgus of right. Transverse of shoulders 10.6 cms. of hips 7.6 cms.

Case 16. Holo-acrania. slight neck, no spina bifida, male. Transverse of shoulders 9.7 cms. of hips 7.1 cms

Case 17. Holo-acrania. Upper cervical spina bifida. male. Right club foot, talipes varus. Transverse of shoulders 12.3 cms. of hips 8.2 cms.

Case 18. The following is a record of a case of anencephaly which occurred in the Lying-in Department of the Birmingham Infirmary, under the care of Mr. Jordan Lloyd, to whom I am indebted for permission to publish it. As resident Surgical Officer, I had charge of this department, and on referring to my record of the cases for the year ending 2nd October 1904, I find that out of 209 births there was one anencephalic.

I attended the woman in her confinement and took the following notes.

Folio 74. J.E. aged 27. A married multipara, admitted on 20th July 1904, in her fourth pregnancy.

History.- Previous pregnancies,

1. female, living.
2. miscarriage at fifth month
3. female, living.

She was last unwell nine months ago. Movement ceased to be felt during the last few weeks of pregnancy.

On examination the abdomen was large and tense, and the foetal parts very indistinctly palpable. Foetal heart sounds were heard faintly in the left iliac fossa. The presentation could not be determined through bulging bag of membranes, which was ruptured artificially allowing a large quantity of liqour amnii to escape. The birth of the shoulders required a little manipulative assistance. The placenta came away with the foetus, which was a stillborn female

anencephalic. It measured 14½ inches, and weighed 3½ pounds (4¼ with placenta). The cord was only 12 inches long.

The points of interest in connection with the case are the sex of her family, all females including the anencephalic. The previous miscarriage, followed by the birth of a healthy child, and then by an anencephalic. The hydramnion, the short cord and the small placenta.

Sixteen of these 18 cases are instances of holo-acrania in eight of which there is also extensive spina bifida, while in ten the integuments of the back are intact the upper cervical arches alone being deficient. The other two cases of anterotubercular mero-acrania without involvement of the vertebrae. The pituitary was present in all of the five cases examined for that purpose. Twelve of the eighteen cases are females. Club foot is present in three of the cases, in two it is bilateral. Statistics of shoulder measurements were obtained from cases Nos. 1.2. .4.5.6.13.14.15.16. and 17. Besides these specimens there were five where the frontals and parietals were present roofing in the cranium. These have not been included in the statistics of sex and shoulder measurements as they are examples of the postero-spinal group of meroacrania which Ballantyne considers apart from anencephaly. Of two of these Nos. 19 and 20, I have obtained photographs and skiagrams.

Case 19. Mero-acrania, Postero-spinal, Female. Weight 1474 grms. Extensive spina bifida. Cranio-spinal defect measures 11.6 cms in length. Scalp extends for a distance of 4.6 cms from the root of the nose on to the base covering the flattened vault bones. The parietals are present articulating with the frontals and supraorbitals. A membraneous sac protrudes from the base posteriorly and hangs over the dorsal region. It contained a solid livery substance. This case is illustrated by photographs and skiagrams.

Case 20. Mero-acrania. Postero-spinal. Cervical and upper dorsal spina bifida. This case is not included in the statistics, but photographs and skiagrams accompany this record. Female. Length 35.6 cms. Weight 1680 grms. The occipitals arching over the vault shelter some fibrovascular debris. Weights of organs.

Liver		85.8 grms.
Spleen		4.1 "
Kidneys	right	5.0 "
	left	5.0 "
Suprarenals	right	.25 "
	left	.28 "
Heart with blood clot.		11.4 "
Lungs	right	12.1 "
	left	9.4 "
Thymus		10.4 "

One of the photographs shows the aplasic suprarenals in situ.

Case 21. This case has been recorded by Dr. Wilfrid Glegg (Brit. Med. Journ. 1. 850. 1899), to whom I am indebted for the photographs taken of it at the time,

which I have added to my collection as they have not been previously published.

The foetus is a good example of the commonest form of anencephaly to which Saint Hilaire gave the name pseudencephalus where the frontals, parietals and occipitals are absent, together with an extensive involvement of the vertebral arches, and the presence of a rudimentary cerebrospinal system. The foetus was a female, measuring 15 inches in length born at the eighth month to a multipara.

I have examined the specimens of Anencephalus in the Teratological Collection of the Royal College of Surgeons in London, with the aid of Thompson Lowne's Descriptive Catalogue. In this Catalogue Class 4 contains the malformations of deficiency of which Subclass 3 details those showing defective development of the somatopleural laminae and is divided into two groups. Group 1 deals with defective closure of the thoracic and abdominal cavities, while Group 2 relating of defective closure of the neural laminae is further subdivided under four heads. 1: Spina bifida; 2.Occipital deficiency; 3 Epicephalocele; and 4 Anencephalus. Subclass 3 recalls the idea of the division into dorsal and ventral canals which underlies all vertebrate development, and illustrates the text in Hirst and Piersol, where this subject is dealt with in connection with the mode of formation of monsters.

Thompson Lowne prefaces the description of the specimens of anecephaly with a statement defining the condition as follows; In Anencephaly the roof of the skull is absent or consists of the membrane bones pushed forward upon the forehead where they form a narrow band or crest; The cartilagenous supraoccipital is always absent and the whole base of the skull is widely exposed. The neural arches of the cervical vertebrae are usually more or less open, they rarely are closed. The brain is frequently absent although sometimes it may be represented by a cyst filled with fluid or blood, or by a cerebroid tumour which protrudes

from the open cranial cavity. The condition arises probably sometimes at least from ulceration of the vertex in the embryo.

This definition, including as it does the idea of "thlipsencephaly" is a liberal one as compared with Saint Hilaire's strict definition of anencephaly while it is more accurate theoretically in embodying the idea ofextensive spina bifida and the condition of the cord as a necessary part of the deformity, but it is rather a restricted definition of acrania being only applicable to the condition holo-acrania of which however it is an admirable exposition. Probably specimens of Meso-acrania are to be found amongst the Epicephalocoeles which I did not examine. The single etiological suggestion offered recalls the idea of intense inflammatory change in the nerve tissues recorded by Vascide and Vurpas, and of Taruffi' s theory of vasular origin deduced by observing the excessive ossification of the bones of the cranial base and the spongy mass occupying the position of the brain. Ballantyne is inclined to be very sceptical of all nosological theories of the causation of anencephaly although he admits that such an explantion might be applicable to pseudencephaly and perhaps it is to this condition that Thompson Lowne refers.

The collection of anencephalus foetuses itself contains various specimens, some dissections and sagittal sections and skulls. Of the sex as recorded in the catalogue I found Nos.345, 346, 357, 358 are females, while

Nos.355 and 356 are males. Thus there are twice as many females as males.

On examing the curvature of the cervical vertebrae in the specimens, I found cervical lordosis present in three out of them. In No.346 it was present to a slight degree. Here only the upper three cervical laminae are dificent, the brain is entirely absent. In No 345 the lordsis in the cervical region is well marked, all the cervical laminae are wanting. In No. 350 the lordsis in the cervical region is very pronounced. All the vertebral laminae as well as the whole axial nervous system are absent. In Specimen No. 349 the cervical vertebrae are perfectly straight. The cervical arches appear to be closed. I noted the position of the tympanic rings which are present in Nos.352, 351, 352a, 353, 354. Ballantyne mentions that these are generally absent. In all of these they are situsted a short distance apart on the inferiot aspect of the cranium and lie inverted so that the tympanic membranes look slightly towards each other. This was the condition of affairs in the case of my own specimen No.1. I exmained the condition of the rings in speciment No.272a, evidently a well marked case of Iniencephaly, and also in specimen 344b, the skull of a case of occipital (posterior fontanelle) encephalocele. In both these cases the rings were much wider apart and looked downwards and outwards, which is the condition present in the normal foetal skull. Another point I looked at was the direction of the

rami of the lower jaw. In all the skulls these ran parallel with each other meeting in the arc of a circle at the symphysis. I have since examined a hydrocephalic foetal skull in the Anatomical Museum in Birmingham and found that both the Gothic shape of the mandibular arch and the widely separated and everted tympanic rings were present in it.

In all the skulls, except in No.352 where they arched over the vertex articulating with the parietals which are present in this case, the lower separated portions of the squamo occipitals form the everted postero external angles of the base and send a process forwards as described in Routh's case (Trans.Obst.Soc.Lond., Vol.37), only they do not join the squamo-zygomatic of the temporal as in his case but are prolonged to the fronto malar junction at the orbit. The only exception was No.352 where the squamo-occipitals articulated with the parietals arching over the base.

(Postero-spinal. Mero-acrania.)

Specimen No.348, is a dissection to show the lobulated condition of the kidneys, which it is stated in the catalogue is a sign of arrest of development. I observed the suprarenals. These appear both abnormally small especially the one on the right side.

Specimens Nos.356 and 357 show adhesion of the amnion in the former to the membrane on the base, in the latter to the peritoneum of ectopic viscera. In a foot note the author admits that adhesion of the amnion to the serous membranes or other defect is a common

complication but he rather ridicules the idea of it's being a cause of these conditions, but rather an effect prone to occur. This rather suggests an inflammatory condition and it is interesting in this connection to remember how the great omentum tends to become attached to inflammatory areas (phagocytic action). No.358 is a specimen with a clinical history. On the exposed base there is a large sac which it is stated was seen to pulsate during the short postnatal existence (20 min), and manipulation of this caused the foetus to cry. Ballantyne quotes four other cases which have cried after birth.

Dystocia.

Abnormal quantity of liquor amnii, usually an excess (hydramnion), with the various complications which this condition engenders, is associated with anencephaly. Other complications such as placenta praevia may exist, as pointed out by Ballantyne. Malpresentation is the rule. Lusk[8] states that transverse and breech are the commonest presentations of this monster. Galabin[9] mentions that these are common, and adds, that when the head presents it usually does so by the face. According to Hirst and Piersol,[10] a face presentation is the commonest. That face presentation is common, when the cephalic end of the foetus presents, might be deduced from such a train of argument as the following. Cases of holo-acrania are the more numerous in the human subject, and in this condition spina bifida is practically a constant association. Herman[11] remarks, that if the defect involves the upper part of the spine as well as the skull the face presents, it may therefore be concluded that face presentation will be common.

Breech and transverse presentation can be attributed to the presence of the hydramnion, but the face presentation has an entirely different explantion. This condition originates in the monstrosity itself, and is caused by the extended state of the head, consequent upon the presence of a fixed spinal curvature in the cervical region, associated with spina bifida.

Photograph Case 2, side view ~~No. 2~~ shows this attitude well and the accompanying section and skiagram demonstrate the extension of the head and the associated spina bifida and cervical lordosis. Delay in labour as a complication may result from the uterine inertia consequent on the hydramnion, from malpresentation of the foetus and shortness of the cord, or by obstruction caused by the foetal shoulders.

Obstetricians are familiar with the delay in the second stage of labour caused by the broad shoulders of the anencephalic foetus. This is noticeable in head presentations, and if podalic version has not been performed, it may be necessary to resort to cleidotomy in order to effect their delivery. In a paper on this operation read on November 14th 1900, by Ballantyne (Scot. Med. and Surg. Journal Vol. 8. 1901 p. 48), he mentions, when dealing with the indications for the procedure, that "in the case of the anencephalic infant the indication for cleidotomy is absolutely clear, for the small head is usually born as far as the vulva easily, through canals imperfectly dilated." This contains the clue to the real cause of the obstruction which is of one disproportion between the size of the foetal shoulders and the maternal canal. This disproportion is due to the relatively small and deformed head acting as a poor dilator, and not to any real increase in the size of the bisacromial transverse diameter, as is generally described. Thus Lusk states that "the shoulders in anencephaly are so unusually broad as to constitute an impediment to delivery."

Herman mentions, among the abnormalities in labour that are commonly associated with anencephalic foetuses, that "theshoulders are often very broad, so much so as to obstruct delivery." In the case of a female anencephalic foetus, weighing 7½ pounds, described by Wishart (B.M.J.1903.1.1319) the expression "especially broad" is used of the shoulders. The head and shoulders are recognised to be larger than the rest of the trunk in normal development. This is ascribed to their purer blood supply. The small deformed head certainly exaggerates the proportions and makes the after coming shoulders appear very broad. In Kennedy's case of a post-mature anencephalic, quoted by Ballantyne (Journ.of Obst.and Gyn.Brit.Emp.2.521.1902), there was delay from the "enormous shoulders" the circumference of which was 42 cms. This however does not necessarily suggest that they were relatively enormous for the size of the child, which weighed 4490 grms. in spite of the absence of brain and vault, for which Ballantyne allows 400 to 500 grms, as, in Sloan's case, mentioned in the same article, which was a post mature normal child, the circumference of the shoulders was greater (43.5 cms.) In two normal cases recorded by Ballantyne (Scot.Med.and Surg.Journ.8.48,1901) both foetuses were less in weight than the one described by Kennedy, yet the shoulder circumference was 41 cms in each of them. Ballantyne records a case of anencephaly where the transverse of the shoulders was 2 cms less than that of the head. He goes on to say "it is common for it greatly to exceed it", but I would point

out that the head is abnormally small on account of the absence of the vault, and the diminution in all the diameters of the case. I have endeavoured to arrive at some definite conclusion on this subject by measuring the transverse diameters of the shoulders and hips (outside deltoid and trochanter measurements), of ten anencephalic and an equal number of normal foetuses, and have estimated the mean ratio in both cases.

Comparison of the Ratios of the Measurements of the Transverse Diameters of the Hips and Shoulders.

	Normal.			Anencephaly.		
No.	H.	S.	R.	H.	S	R.
1.	10.0	15.6	1.56	8.3	10.9	1.31
2.	9.4	14.2	1.51	9.1	13.3	1.46
3.	10.1	15.0	1.48	7.6	10.6	1.39
4.	5.3	9.0	1.70	7.1	9.7	1.36
5.	6.6	10.9	1.65	8.2	12.3	1.50
6.	4.9	7.7	1.57	8.6	11.4	1.33
7.	5.6	8.9	1.59	6.3	8.6	1.36
8.	5.9	9.4	1.59	6.7	9.5	1.44
9.	6.0	10.1	1.68	7.6	9.9	1.30
10.	10.6	15.8	1.49	7.5	10.3	1.37
		10	(15.82		10	(13.82
	mean ratio		1.58	mean ratio		1.38

In relation to their respective hips, it will therefore beseen that the ratio of the shoulder transverse diameter of the normal foetus is greater than that of the anencephalic and, since the hips may be taken as a uniform basis for comparison it follows that the shoulders of anencephalics are really narrower than normal. Tneir apparent hugeness must be regarded as an optical illusion rather than an anatomical anomaly. The fact remains however that they are often the cause of dystocia for the reason mentioned.

Premature labour is also associated with hydramnion. The labour that ends in the birth of an anencephalic foetus is generally premature. Birth is usually considered premature when it occurs between the 196th day of gestation, when the foetus normally becomes visible, and the normal onset of labour on the 276th day. Saint Hilaire referring to his species anencephalus, mentions that they are born generally in the course of the eighth month. Is the premature labour in this case to be ascribed to the anencephalic foetus, or to the hydramnion? Ballantyne points out, that anencephaly is a common association of post maturity, and he ascribes this to absence of the liquor amnii, and on the part of the foetus to the absence of cranial vault at the maternal pelvic brim. This suggests that the foetus, apart from the hydramnion it may be instrumental in producing, is not the exciting cause of the premature birth, unless it can be adduced that extreme degrees of the deformity may be incompatable with prolonged intrauterine existence. Ballantyne in his paper "The Problem of the Postmature Infant" gives it as his opinion that certainly in most cases of anencephaly labour occurs prematurely, adding that hydramnion is usually present which excites premature labour by overdistending the uterus and so inducing pains. He draws attention to the usual scarcity of liquor amnii in anencephalics. On the other hand in Maidlow's case which Ballantyne quotes as one of postmaturity I find on looking up the reference(Lancet.2.970.1902.) that "the liqour amnii

deluged the bed". This seems rather to contradict both the idea of postmaturity being due to oligohydramnion and of hydramnion as a certain cause of prematurity. The occurrence of ologohydramnion in anencephaly argues against the theory as to the source of that fliud being cerebrospinal.

Before leaving the subject of labour in connection with anencephaly I would draw attention to the fact that many of the cases in literature were born to primiparae. As examples of this I may quote the following references.

Cases of anencephaly in primiparae.

Primipara aet. 28 Lancet 2.1712.1904 (Beattie's case)
" " " 25 "" 2 990.1902 (Maidlow's case)
" " " 16 B.M.J. 1.1319.1903 (Wishart's case)
" " " 25 " " " 2.1769.1896 (Brayne & Stuck)
" " " 22 Tr.Obst.Soc.Lond.10 37 (Langston)
" " " 19 J.Obst.Gyn.Brit.Emp.2.521.1902
(Ballantyne's 6th case)
" " "young" Antenatal Path. 2 335 (Otto's case)
Ballantyne.
" " " " " 2.355 (Carli's case)

The Sex in Anencephaly.

Anencephalic foetuses are usually females. It is questionable how much sex has to do with the condition whether the predominance of females is merely a coincidence, or has some deeper etiological significance. Coats,[13] dealing with the influence of sex in disease, states, that "it is a remarkable fact that apparently in all lands there are more male children born than female, and again, that "at nearly all periouds of life the female is less susceptible to disease than the male." W.R.Williams,[14] in a paper on the same subject in 1885, says, that as a rule congenital defects are much commoner among males than among females, but gives spina bifida as an exception. Now spina bifida is the second commonest malformation and anencephaly a common monstrosity. These two conditions are often associated, and it is interesting to find these types of the commoner malformations as exceptions to the general rule of male sex predominance in congenital defects. Geoffroy Saint Hilaire recorded, that anencephalics are usually females. Förster, according to Ballantyne, doubts its greater frequency in either sex. I was struck by the preponderance of females in the eighteen cases that I examined (12:6) and made a note of the sex of the cases met with in the course of my reading, of which the following is a list.

Record of Sex in Anencephaly.

Reference	Sex. F.	Sex. M.
The earliest case referred to in literature, (Lycosthenes' case 1557)	1.	
Lancet 2.1902. (Maidlow's case)		1.
" " 2.1904 (Beattie's case)	1.	
Brit. Med.Journ.2.1896. (Brayne & Stuck)	1.	
Brit. Med. Journ. 1. 1897 (Carstairs Douglas)		1.
Brit. Med. Journ. 1.1903. (Wishart's case)	1.	
Trans.Obst.Soc.Lond.Vol.10.(Lloyd Robert)	1.	
Trans.Obst.Soc.Lond.Vol.10.(Langston)	1.	
Trans.Obst.Lond.Vol.31 (Griffith)		1.
Trans.Obst.Soc.Lond.Vol.35 (Routh)	1.	
Trans.Obst.Soc.Lond.Vol.35.(Ballance)	1.	
Trans.Obst.Soc.Lond.Vol.38 (Stevens)	1.	
Journ.Anat.and Phys.Vol 27. (Windle)	5.	5.
Journ.Anat and Phys.Vol.22 (Cunningham)	1.	
Journ.Anat.and Phys.Vol.19.(Shepherd)	5.	1.
Journ.Anat.and Phys.Vol.23 (Shepherd)	2.	1.
Manual of Antenatal Pathology 2.336(Ballantyne)	30	6.
Karl Biessing,qouted by Ballantyne,ibid.2.346.	10	6.
Teratological Collection Roy.Col.Surg.Eng.	4.	2.
Specimens examined by myself.	12.	6
	78:	30.

Thus, out of the first 108 cases taken as they came including my own, the proportion of females to males is 78:30; an enormous predominance of the female sex. I have excluded from these statistics five specimens in the collection of the Birmingham museums of Anatomy and Pathology, and several in literature, amongst others the one recorded by Hughes (Lancet.2.1887.) as they are members of the postero-spinal variety not included in Ballantyne's classification of anencephaly. I have also omitted Case No. which was recorded by my brother (B.M.J.1.1889.) as the foetus is in the possession of Dr.Ballantyne (279), who no doubt includes its sex, a female, in his statistics incorpoated in the above list.

Cunningham (Journ.Anat.and Phys.22.391.) points out a possible source of error in sex statistics that has to do with geographical distribution. He finds that different anatomical departments show a variation in the proportion of the sexes dissected. Thus in the Edinburgh and Dublin schools female subjects are always in excess of male subjects. Bordeleben, quoted by Cunningham, states, that on the Continent males are more frequently dissected. This may account for the opinion held on the subject by Förster and Meckel who do not find such a preponderance of females in anencephaly.

McClintock[15] found that about 75% of foetuses born with hydramnion were females. Hydramnion and anencephaly are usual concomitants of each other.

Are anencephalics female because of their association with hydramnion? Kennedy's case of anencephaly with oligohydramnion recorded by Ballantyne (Journ.Obst. and Gyn.Brit. Emp.2.521.1908.) was a male. He has not recorded the sex of Martin's case, and in Lundy's case, a female, the quantity of liqour amnii was not determined. W.H.Maidlow's case which he quotes was a male, but here the liqour amnii was plentiful. These cases do not appear to support my contention.

The Skiagrams.

Some importance is to be attached to the osseous system in anencephaly from the fact that Taruffi makes the condition of the bones of the cranial vault the basis of his classification of these monsters. Ballantyne's statement (Lancet 2.530.1902) that "anencephaly results from arrest of formative processes of a part of the skeleton" and Recklinghausens theory of primary aplasia of the skeletal axis gives it an etiological interest. Then there are such peculiar conditions as deficient ossification of the membranous cranial bones in contrast to the fact that the rest of the skeleton is ossified and the excessive ossification of the base which Taruffi has noted. This irregularity of ossification is seen in the persistence of the basiotic observed by albrecht in connection with anencephaly. Cunningham[16.] states that this normally fuses with the basiocciput about the 6th week of foetal life. Its persistence as a separate element must be regarded as an example of under ossification. This condition is not peculiar to anencephaly as it may occur in other subjects. The union of the basisphenoid with the basiocciput mentioned by Ballantyne which does not normally take place until the 25th year must be considered as either over ossification or the result of compression as in the cervical vertebral fusions. Then there are those instances of over ossification occurring in postmaturity recorded by Ballantyne of which the

presence of a state of ossification for the lower epipysis of the humerus which usually appears about the second or third year (Cunningham) is the most remarkable, and contrasts still further with the aplasia of the cranial vault in the same specimen. Then there are the fixed curvatures of the cranio-vertebral axis, abnormal for the period in which they are present. The relation of these curvatures to the open condition of the spinal arches and of the cranial vault is instanced by the association of a lordotic cervical curvature with spina bifida, and by the presence of holoacrania with a greater sphenoidal angle than occurs in mero-acrania.
In development the last portions of the neural arches to close are those situated opposite the flexures. Ballantyne observed the fact that in an anencephalic foetus with a well marked neck there was no spina bifida, which suggested that spina bifida might have to do with the neckless condition usually found in anencephaly. Hirst and Piersol explain that cervical lordosis (which produces shortness of the neck), results from the deficiency of the vertebral laminae weakening the arch.
Might not the order be reversed and the persistence of a curvature normal in the embryo at the third week hinder the proper formation of the neural arches? That cervical lordosis may exist without the spina bifida is exemplified in the condition of affairs in mongolian imbeciles in whom the neck is

shortened by the presence of cervical lordosis. Spina bifida is not necessarilly associated with anencephaly, but in the more complete form holo-acrania it is an almost constant occurrence to a greater ot less extent. It was present in all of my sixteen cases, very extensive in eight of them and limited to the upper cervical region in the others. Various curvatures of the cranio-spinal axis are present. I observed in the case of the skull which I prepared from Case 1. that there was a scoliosis of the cranial base which was continued down the cervical region in the opposite direction. The sphenoidal angle is a kyphotic curve. Lordosis in the cervical region seems to be the rule. Ballantyne found it present in fifteen out of sixteen cases. It is the condition present in the skiagram and in Case 3. The section I prepared of the head and neck of case ? as will be seen from the photograph, shows this condition well.

Cervical kyphosis is rarer. I observed it in a sagittal section of an anencephalic foetus in the anatomical museum in Birmingham, a case of holo-acrania with the extensive spina bifida. The cervical kyphosis was well marked. There was upper dorsal kyphosis as well so that there was a promintary formed at their junction. Lordosis was present in the lower dorsal region and kyphosis in lumbar.

With a view to investigating and illustrating some of

these points I have had skiagrams taken of four specimens. Ordinary photographs were taken at the same time in order to form a complete reference. The cases selected are Nos. 1,2,19 and 20.

On the subject of radiography in anencephaly little if indeed anything has been recorded by English observers, if one may judge from reference to the Archives of the Roentgen Rays, or the Index Catalogue of the Surgeon-Generals Office, Washington 1906. In the latter mention is made of the following. Bouchacourt (Etude des monstres par les rayons de Roentgen. Bull. Soc. d'Obst. de Par. 1899. 2. 76-79.)

Villers (Presentation de la radiographie de quelques monstres, Bull. Soc. d'Anthrop. de Brux. 1901-1902. 20. p. 68). I am not in the position to say whether these contain anything on the subject of anencephaly or not as they are not in either the Library of the Royal College of Surgeons or in the Medico Chirurgical Society's Library. I have examined the article by Lewers (Trans. Obst. Soc. Lond. (1897) 1898. 39. 131.) " A monster with Skiagram", and I find it is a description of a spherical mass with one limb the skiagram showing that in the apparently shapeless mass there is a fairly complete skeleton, the bones of the two lower limbs being present in what seems to the naked eye to be one limb only. I noted that the cranial vault presents it's normal contour.

Since the osseous system in anencephaly possesses so many points of interest on both structural and theoretical grounds, a rapid method of obtaining an accurate and permanent record of it in situ, preserving at the same time the integrity of the specimen, is much to be desired. Such a method is at our service in radiography. By its means the condition might be diagnosed in utero. Skiagrams of the monster after birth will show the condition of the ossification in the skeleton generally, and the local irregularities and deficiencies in the cranio-vertebral axis. The presence of unusual centres of ossification, such as occur in post maturity, can be demonstrated. The interpretation of the skiagrams requires a certain familiarity with the appearance of such photographs, which are sometimes misleading, and with the anatomy of the object itself. The chief advantage possessed by this method of investigation over dissection is the production of a permanent record without mutilation of the specimen. It will be difficult, however, to find any method that surpasses careful dissections, and accurately made diagrams. Details, that are apt to be obscured by surrounding structures, such as the tympanic rings and ear ossicles may be difficult to demonstrate by skiagrams. The expenses connected with radiography are also a disadvantage. Skiagrams and photographs of the four cases selected were taken at my

direction by Mr Hall-Edwards. The foetuses were exposed in the first instance lying on their backs, so that the dorsal structures being next the plate had the best exposure, and then lying on one side to obtain a lateral exposure. On examination a general survey of these skeletons shows the ossification of the shafts of the long bones, and the intervening unossified epiphyseal areas, There is a centre for the lower end of the femur (9th-10th month) visible in Case 2 (S2). The centres for the astragalus and os calcis were visible in Case 1 (S2) in a proof of the photograph. Contrasted side views of the skulls show that the base is uncovered by bone in Cases 1(S2) and 2(S2), while the anterior part of the base is covered by the frontals, parietals, and occipitals, in Cases 19. (S2) and 20. (S2). The direction of the base in Case 1 (S2) is almost directly upwards, while in Case 2 (S2) it looks backwards. The hyperprognathism of the lower jaw is well seen in the latter skiagram.

The direction of the base might appear to depend on the extent of the spina bifida when Cases 1 and 2 are contrasted. In the former there is only slight spina bifida, while in the latter it is extensive. Ballantyne states that the backward direction of the base is the most typical one. The back view (Case 1 S1) shows the central sphenoid with cartilaginous intervals between it and the adjacent bones of the base on either

side. In this instance the photograph is useful in showing that fusion has not taken place between them as Ballantyne mentions may be the case. The supra-occipitals are seen to be depressed on either side of the base, in Case 20 (S1), they arch over the base and the parietals can be seen beyond. In Case 2 (S1) the shadow of the separated halves of the supra-occiput can be seen forming the postero-external points of the base with that of the clavicle beyond. Their antero-lateral processes can be traced forwards. The condition of the vertebral column can be studied. The cervical region differs in all four skiagrams, although all show a varying degree of lordosis which is slight in Case 1 (S2), well marked in Case 2 (S2), while in Case 19 (S2) it is so extreme that the upper cervical vertebrae are reflected upon the lower to which they are closely approximated. In Case 20 (S2) the lordosis is least marked, and there is an almost straight condition of the whole spine differing from Case 1 (S2) where the normal foetal curvature with its anterior concavity is present only broken above by the slight retroflection of the cervical vertebrae. A compensatory kyphosis is present in the dorsal region in Cases 2 (S2) and 19 (S2).

Lateral curvatures of the spine can also be seen. In Case 1 (S1) there is scoliosis in the cervico-dorsal region with its concavity to the left. A similar condition is present in Cases 20 (S1) and 19 (S1), while in

Case 2 (S1) it is in the opposite direction. In this case, and in Case 20 (S1), fusion or irregular ossification of the centra marks the central area of the scoliosis. The greater breadth of the ossified lumbar centra contrasts with the smaller dorsal centra. The large size of the third and fourth lumbar vertebrae in Case2 can be seen both in lateral and posterior exposures. The number of the vertebrae is abnormally increased in Case 1, where There are seven cervical, thirteen dorsal, an additional poorly ossified centrum occurring in the lower dorsal region at the level of the ninth rib, six lumbar and five sacral. The coccyx is unossified. In Case 20 (S1) the spina bifida extended as low as the seventh dorsal vertebra. The expanded laminae can be seen in the skiagram in this case and compared with the condition present in Case 1 (S1). where the spina bifida was limited to the upper cervical region. In Case 2 (S1) where the spina bifida was mor extensive than in Case 20, the widely separate condit--ion of the laminae extends to the lumbar region as may be seen by comparison with Cases 1 and 20, where the laminae are seen as parallel rows of ossification closely approximated to the vertebral centrae. An expanded condition of the laminae can also be seen in Case 19 (S1), where spina bifida is so marked a feature of the specimen.

Microscopic Slides.

1. Section of retina from Case 2 (Van Gieson's stain).
2. " " eye " " " " " " .
3. " " suprarenal " " " " " " .
4. " " pituitary " " " " " " .
5. " " " " " 8 (Haidenhain's stain).
6. " " " " " " (Mann's stain).
7. " " " " " " (Erlich's triacid stain).

Photographs and Skiagrams.

Cases 1.2.19.20.

Photographs of viscera showing suprarenals.from Cases 1.2.20.

Photograph of sagittal section of head and neck of Case 2.

Photographs of skulls.

Photographs of Cases 5 and 7, and of Case 21.

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